



THOR

Tera Hertz Operational Reachback

“Network-Enabled Free-Space Optical Communications”

DARPA/ATO
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THOR 101 A Review

- Leverage the extensive deployment of terrestrial fiber
 - ✓ Extend fiber to the theater via a mobile free space optical path
 - ✓ Provide broadband (fat pipe) communications into/and out of the theater
- Use improved technology within the context of a network to mitigate Mobile Free Space Optical limitations
- THOR strives to achieve, compared to the best current tactical RF link:
 - ✓ 40X improvement in data rate
 - ✓ 10X reduction in size, weight and power
 - ✓ at least a 10X reduction in cost
- Deployed on Demand
 - ✓ Where and when its needed
 - ✓ Extensible
- Augments the GIG
- Full Duplex
 - ✓ High bandwidth push / pull
 - ✓ Routing diversity
- Networked for Availability
 - ✓ Robust
 - ✓ Ad Hoc

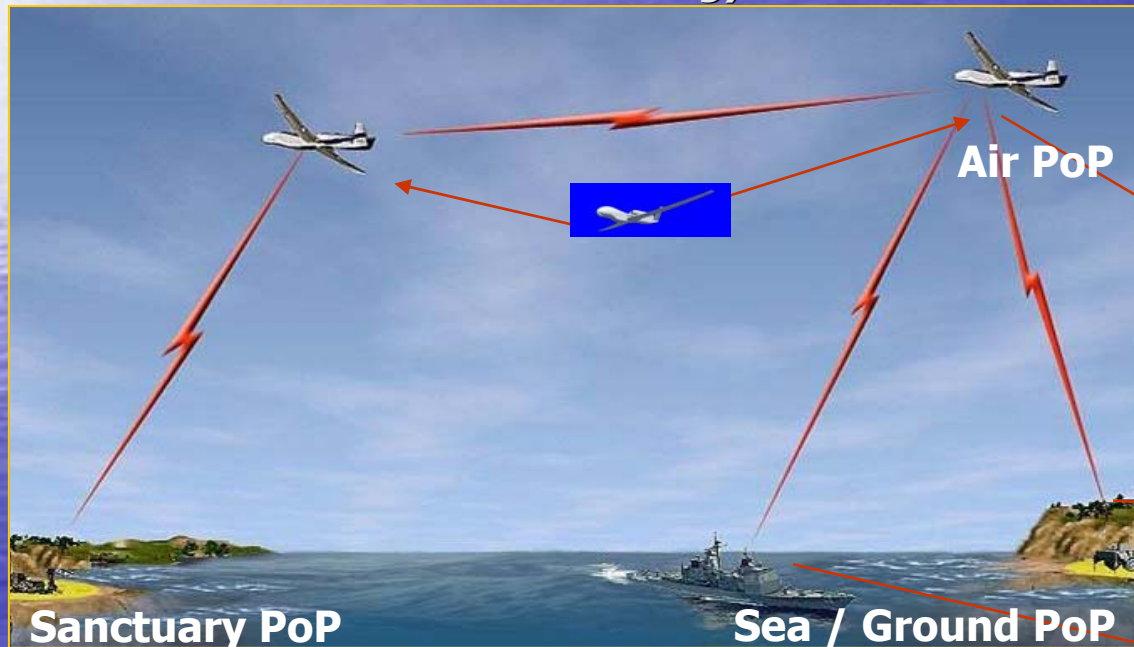
Where THOR Fits

Primary Dissemination

*Current Customer Base For
THOR Technology*

Secondary Dissemination

*Future Customer Base
For
THOR Technology*



Sanctuary PoP

Sea / Ground PoP

Air PoP

**Air Force
(DTIG/Etc)**

**Army
(WIN-T/FCS/Etc)**

**Navy/Marine Corp
(NMCI/IT-21/NFN/Etc)**

Notional PHASE 3 DEMONSTRATION Architecture.

This is NOT necessarily THE ops concept.

THOR and Transformation Communications

- TCA is emerging
- THOR can help
 - ✓ THOR may provide a near-term capability (G-A-G demo FY06)
 - ✓ Test technologies and concepts
 - ✓ Interfaces
 - ✓ Air node
 - ✓ Ground node
 - ✓ MFSO Networking

THOR Program Schedule

FY02

FY03

FY04

FY05

FY06

Technology Push

10 month PoP

Technology Innovation & Maturation
System Architecture, Concept, and CONOPS
Many Technology Investigators

- DRAFT BAA Amendment RFC Dec 02
- Industry Day and PI Meeting II 4-6 Feb 03
- BAA Amendment Release 14 Feb 03
- THOR Phase 2/3 Proposal Due 14 Mar 03
- Contract Award June 03

Acq

Phase I

Technology
Lab
Demos

PI
Meetings

Subsystem Development

20 month PoP (10 month base/10 month option)

Total Value
See BAA

Acq

Phase II

Refine System Architecture, Concept
& CONOPS

Subsystem
Lab
Demos

Subsystem
Demos

Subsystem Technology Development
• Network Modeling
First 10 months >2 teams
Next 10 months >1 teams

Tech Opportunities

Plan to fund novel ideas under DARPA ATO
Office BAA 03-06

Technology Integration & End-to-End System Demonstration

24 month PoP

Expected
Value
See BAA

Acq

Phase III

Final
Demo

Refine System Architecture,
Concept, & CONOPS

Network Modeling, Flight System Prototype, &
Flight Demonstration --- Single System Integrator

TRL3/4

TRL5/6

TRL7

Scope of Phase 2 & 3

- 9 Actual System prove through successful operations
- 8 Actual system completed and qualified through test and demonstration in the actual environment
- 7 System prototype demonstration in the actual environment
- 6 System/subsystem prototype demonstration in a relevant environment
- 5 Code, component, breadboard validation in a relevant environment
- 4 Code, component, breadboard validation in a laboratory environment
- 3 Analytical and experimental critical function and characteristic proof of concept
- 2 Technology concept and application formulated
- 1 Basic principles of the technology observed and reported

Phase 3

Phase 2b

Phase 2a



Available from Phase 1 study efforts

- MIT/LL Notional Architecture

- ✓ THOR Strawman Architecture to include:
 - ✓ Methodology - Network Design - Terminal Design - Clouds, Atmosphere, and Turbulence studies
- ✓ Guidance on tools to use for analysis
- ✓ Technology assessment

- ITT

- ✓ THOR System Concept, System Architecture, and CONOPS
- ✓ THOR Technology Roadmap
- ✓ THOR Architecture trades and assessment through the application of OPNET and COTS channel models, link budgeting and hardware performance tools

Anticipated Deliverables

Phase 2a	Phase 2b	Phase 3
<ul style="list-style-type: none">✓ TRL ~ 3/4 Demonstration✓ Preliminary CONOPS✓ Preliminary Architecture✓ Preliminary ROMs	<ul style="list-style-type: none">✓ TRL ~ 5/6 Demonstration✓ THOR Transition Plan✓ Refined CONOPS✓ Refined Architecture✓ Refined ROMs✓ Full Phase 3 Proposal <i>-(Proposal due ~8 months after Phase 2b starts)</i>	<ul style="list-style-type: none">✓ TRL ~ 7 Demonstration✓ Refined THOR Transition Plan✓ Final CONOPS✓ Final Architecture✓ Final ROMs

ROMs will address: life cycle cost; SWaP; and RMA metrics

Discriminators for Phase 2

- Architecture – Terminal & Network
 - ✓ Modular, Open, Scaleable, and Innovative Design
 - ✓ Core framework for a family of terminals
 - ✓ Ability to incorporate legacy comms
 - ✓ Cost & Producability Potential
 - ✓ Demonstrations proposed
 - ✓ Network Modeling and Simulations
- Innovative Concept of Operations and Employment
- Risk Management – Technical and Programmatic
 - ✓ Team Composition
 - ✓ Transition Plan

General BAA Comments & Responses

- "Do we really have to meet the 33 dB link margin and other challenging specifications?"
 - ✓ No. There are no hard specifications. The final BAA will reflect this. The focus is on system efficacy and maximizing network backbone quality of service .
- Q. "Is electronic beamsteering mandatory?"
 - ✓ Not, in and of itself. The exact technology is not the focus. Minimize SWaP, maximize field-of-regard, and other key system parameters.
- Q. Can performers use interim technologies for Phase 2a and 2b demonstrations?
 - ✓ Yes. Suboptimal technologies are acceptable if a path to a final acceptable solution can be achieved by the Phase 3 Demonstration
- Q. Can RF links be used for ancillary purposes such as set-up and PAT?
 - ✓ Yes.



Red Herrings

Belief in the following may be misleading:

- Phase 1 performance is a precondition for Phase 2/3
- Having a Phase 1 performer on your team is necessary for your Phase 2/3 proposal
- Retro-reflectors must be part of your architecture
- The notional Phase 3 demo picture is the right answer
- Meeting the Go/No Go metrics insures success
- This is only an Air Force program
- Demonstrations are not important

Co-Opetition

- Cooperation + Competition = Co-Opetition
 - ✓ Cooperation – how we create value (how we create the pie – create the market)
 - ✓ Competition – how we capture value (how we grab our slice of the pie – carve up the market)
- DARPA provides venture seed funds for future DoD (and possibly commercial) program(s)
 - ✓ Companies need to take a long view and commitment to creating a new business area
 - ✓ Companies need to closely examine the potential business case and decide if they want to be a free space optical communications system provider
- The end state sought is *transition* to the Service(s) for production.